HUMAN EYE

IDEA TO REMEMBER!

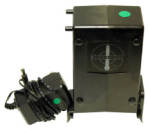
Positivity brings things closer; negativity pushes things away!

OBJECTIVE:

Study the optical characteristics of the human eye and medical conditions that affect it using a model eye.

MATERIALS:

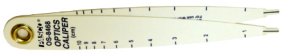

Optical bench


Light source


Eye model bracket


Human eye model


Human eye lenses



Optical caliper

Colored pencils


Ruler

CONCEPT:

Since we have been looking at light waves, let's take a fun detour into the field of optics, specifically the most advanced optical instrument in the Universe—your eye! In fact, the brain is the only organ that is more complex than the eye.

Human eyes are special sense organs that can receive visual images and transmit them to the brain. Eye conditions and vision issues come in a huge variety. For example, an estimated 75% of adults age 25 and older need vision corrective technology—read the Fun Fact. While many others are treatable, some have no treatment. We go over a few of them and their solutions in this practical.

FUN FACT: Most people experience the power of lenses on a daily basis. Remember that a convex lens has a positive focal length to bring an image forward or *closer* to itself, while a negative (concave) lens pushes the image *away* from itself. In this way, you might say, **Lenses are like people!**

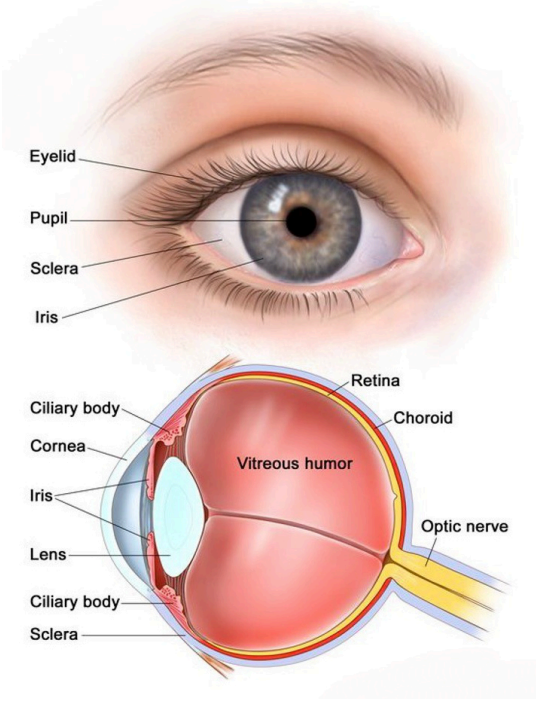


Figure 1

The cornea, iris, pupil, aqueous humor, lens, vitreous humor, retina, and optic nerve are the major structural components of the human eye, see Figure (1).

Cornea: This is a transparent layer, that allows light to enter the eye and acts as a shield for the front of the eye. It also helps to focus light on the retina at the back of the eye.

Iris and Pupil: The iris is the colored part of the eye that surrounds the pupil and closes or opens to regulate the pupil's size, which controls the amount of light entering the eye.

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Aqueous Humor: This is the fluid behind the cornea that nourishes the eye and helps shape the cornea.

Lens: The lens is located behind the iris. It directs light onto the retina by altering its shape.

Vitreous Humor: To focus light, a specific distance is needed. This distance is possible because to the vitreous humor, a clear, watery gel that supports the eye.

Retina: It is a layer that is sensitive to light and is made up of many nerve cells. It transforms the wavelengths from the lens image into electrical impulses that are then sent to the brain for interpretation via the optic nerves.

Optic nerve: Signals are sent from the retina to the brain via the optic nerve, a thick bundle of nerve fibers.

In this lab demonstration, we use a human eye model to explore several eye conditions related to the lens and retina.

Real World Applications

- **Eyeglasses** and **contact lenses** correct myopia and hyperopia that more than 75% of people develop with age or a modern lifestyle.
- There are nine types of eye surgeries mostly dealing with lens issues. The most common are **PRK** (photorefractive keratectomy), **LASIK** (laser in-situ keratomileusis), **LASEK** (laser subepithelial keratomileusis), and **SMILE** (small incision lenticule extraction).
- 2009 was the world's first trial of the Argus II bionic eye implants performed by surgeons at Manchester and Moorfields on Professor Stanga. Additionally, in 2015, a patient with age-related macular degeneration (AMD) received the first ever bionic eye implant.

1) You won't believe your eyes!

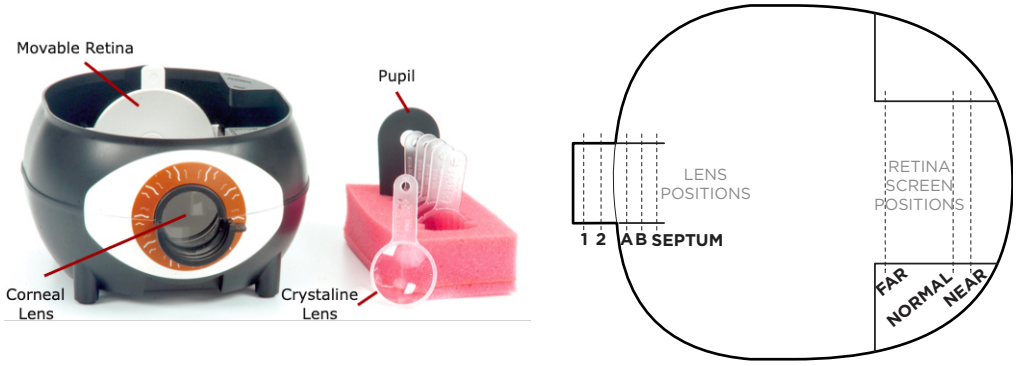
2) Surgery comparison.

PRECAUTIONS:

Not much for worry! Have fun and learn!

PROCEDURE:

Figure (2) provides a schematic for the human eye model, and Table 1 details the available lenses. The cornea is represented by a permanently placed plano-convex glass lens. The aqueous and vitreous humors are modeled by the water that is added to the tank. A plastic lens placed behind the cornea in the SEPTUM slot represents the crystalline lens of the eye. The retina is represented by the moveable screen at the back of the model, which slides into the places labelled FAR, NORMAL, and NEAR. Corrective lens can be placed in front of the cornea in slots labelled 1 and 2.



(a) (b)

Figure 2

Table 1

Lens Type	Focal Length (mm)	Power in Diopters
spherical convex	+120	+8.33
spherical convex	+62	+16.00
spherical convex	+400	+2.50
spherical concave	−1000	−1.00
cylindrical concave	−128	−7.81
cylindrical convex	+307	+3.25

1. ☐ Fill out the top information on the worksheet **and** complete the memory exercise—Questions M1–M3.

2. ☐ REQUIRED: Read the *Concept* section.

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CONCEPT & PROCEDURE VIDEOS:

3. ☐ Assemble the setup as it is shown in Figure (3).
   - 3.1. Fill the tank with water until it is 1–2 cm from the top.
   - 3.2. Keep the retina in the middle position (NORMAL) and place the +62 lens in the SEPTUM.
   - 3.3. Place the light source (object) at one end of the optical bench, and place the eye model on top of the bracket somewhere in the middle of the optical bench, then change the distance of the light source (object) until you have a sharp, focused image on the retina.

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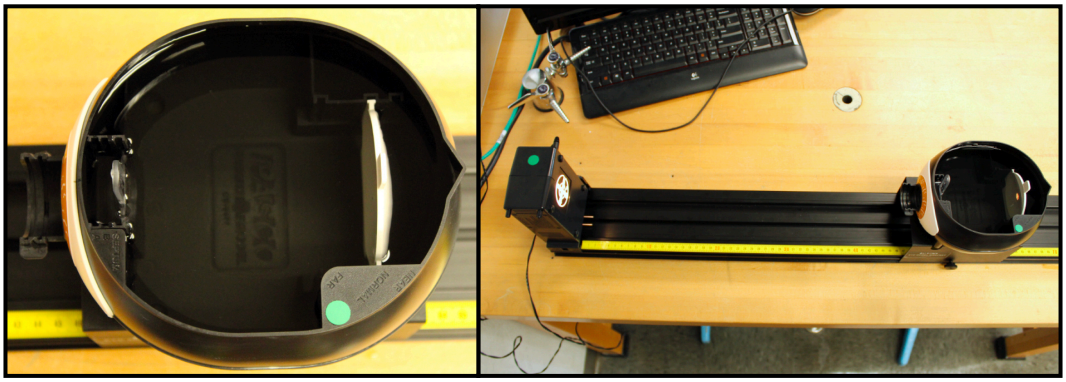

(a) (b)

Figure 3

Accommodation

Accommodation of the eye is the process of biologically altering the crystalline lens components to change the refractive power and sharpen the focus of objects that are nearer to the eye.

4. ☐ Study the light source graphic and the differences in the image inside the eye.

5. ☐ Place +120 lens in the SEPTUM position and study the new image. (Do not move anything.)

6. ☐ Answer Question 1 on the worksheet.

Use of a Magnifier

Magnifiers produce an image at a set distance from the eye. The eye must adjust to this distance. Reading glasses should be worn if the eye can no longer focus on the image clearly at this distance.

7. ☐ Return the +62 lens to the SEPTUM.

8. ☐ Measure and record the size of the image (h_i) on the retina and the same part of the light source (object, h_o). Use an optical caliper to measure the height while underwater, then take the caliper out of the water and put it against a ruler.

9. ☐ Record the measurements in Table 2 on the worksheet.

10. ☐ Place the +120 lens in slot 1 or 2.

11. ☐ Change the distance of the light source (object) until you get a clear image.

12. ☐ Repeat step 8 and 9.

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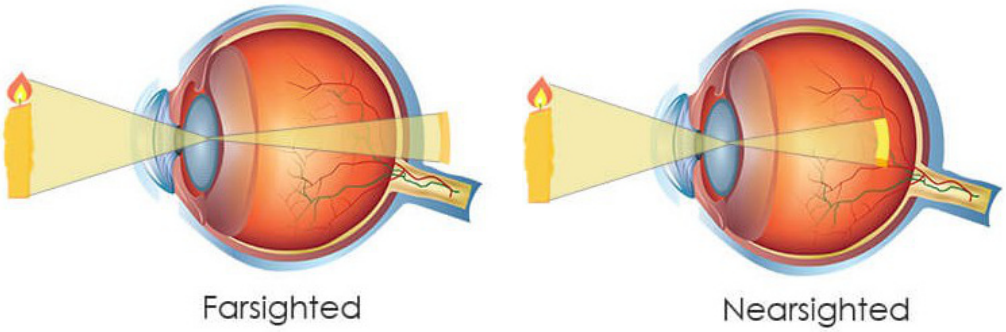
Farsightedness and Nearsightedness

While farsightedness (hyperopia) arises from the visual picture being concentrated behind the retina rather than directly on it, nearsightedness (myopia) is the condition where the image is focused in front of the retina. Both conditions cause blurred vision. See Figure (4).



(a) (b)

Figure 4

13. ☐ Keep the +62 lens in the SEPTUM position and create a sharp image inside the eye by adjusting the object distance.

14. ☐ Move the retina to the FAR position.

15. ☐ Note the blurry image. Fix the image by inserting the proper corrective lens into slot 1 or 2.***

16. ☐ Answer Question 2 on the worksheet.

17. ☐ Move the retina to the NEAR position and remove the corrective lens.

18. ☐ Note the blurry image. Fix the image by inserting the proper corrective lens into slot 1 or 2.***

19. ☐ Answer Question 3 on the worksheet.

*** If you place the retina back in its normal (middle) position now without taking out the corrective lens. This is an example of what happens when someone with normal vision wears someone's glasses.

Astigmatism

If your cornea or lens are not shaped normally, astigmatism will occur. You may experience hazy or distorted vision as a result of this common eye condition, see Figure (5).

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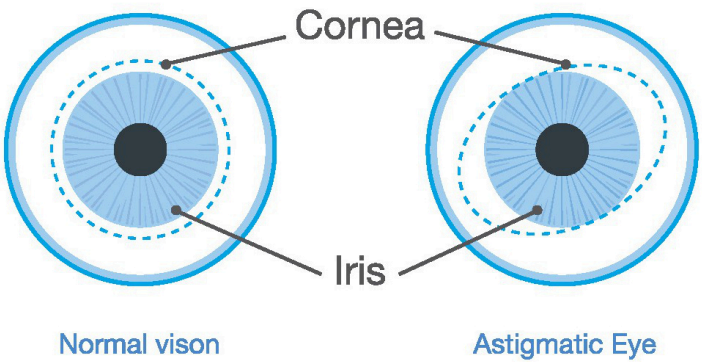

Figure 5

20. ☐ Remove the corrective lens from the last exercise, keep the retina in the NEAR position, and place the –128 lens behind the cornea in slot A.

21. ☐ Rotate the lens to change the defect's orientation.

22. ☐ Note the blurry image. Fix the image by inserting the proper **two** corrective lenses into slot 1 or 2. (Hint: Rotate the sample corrective lenses.)

23. ☐ Answer Question 4 on the worksheet.

Absence of the Crystalline Lens

Aphakia is a condition when there is no crystalline lens in the eye, which results in blurry vision. See Figure (6). The term "aphakic eye" refers to those who have this condition. A person may be born with this issue or lose it from injury, but cataract surgery is a cheap and painless way of replacing this lens. In fact, people over 55 years old often elect cataract surgery since the crystalline lens becomes hazy or "wears out" by this age from years of light exposure.

24. ☐ Remove the corrective lenses from the last exercise, place the retina in the NORMAL position, remove the –128 lens from slot A, and remove the crystalline lens from the eye model (SEPTUM).

25. ☐ Note the blurry image. Fix the image by inserting the proper **two** corrective lenses into slot 1 or 2.

26. ☐ Answer Question 5 on the worksheet.

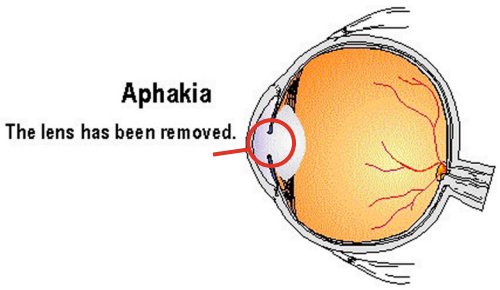

Figure 6

Impact of the Pupil

How much light enters the eye is regulated by the pupil. Our pupils widen at night to let in more light and improve our eyesight. To enable us to see normally in the sunlight, our pupil narrows to a very small diameter.

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27. ☐ Remove the corrective lenses from the last exercise, place the +62 lens in the SEPTUM position, and place the little, round Pupil hole in slot A.
28. ☐ Answer Question 6a on the worksheet.
29. ☐ Move the light source closer—this will brighten the light but also blur the image.
30. ☐ Flip the Pupil around so that the narrower hole is behind the cornea.
31. ☐ Answer Question 6b on the worksheet.

Clean up

32. ☐ Remove all lenses from the model and gently dry before returning to their foam carrier.
33. ☐ Pour the water in the model into the lab sink.
34. ☐ Turn off the light source.

Color Vision and Blind Spot

35. ☐ Ask your partner to stand behind you and grab an undisclosed, colored object. They will hold it behind you about two feet away from one side of your head and slowly move it forward while you maintain a straight-ahead focus on a fixed object.
36. ☐ Tell your partner when you first notice the object and again once you can tell what color it is. Your partner should take note of the angle for both instances.
37. ☐ Answer Question 7a and 7b on the worksheet—Figure (7) on the next page.
38. ☐ Next, use the X and O on the worksheet to determine your blind spot:
    - 38.1. Hold the paper in front of you.
    - 38.2. Close your left eye.
    - 38.3. Position the X in front of your nose (the O should be to the right).
    - 38.4. Move the paper closer to your eye until the O disappears.
    - 38.5. Ask your partner to approximate the angle that it disappears.

38.6. Repeat step 38 for your left eye.

39. ☐ Answer Question 7c and 7d on the worksheet.

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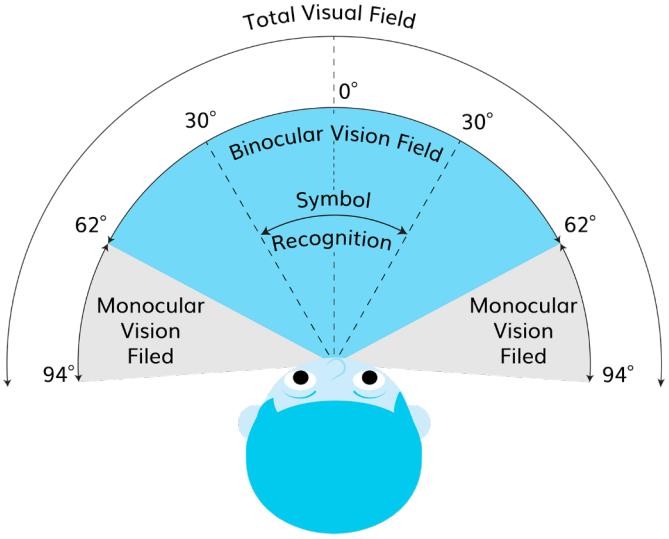

Figure 7

40. ☐ Follow the **Let's THINK!** instructions below.

Let's THINK!

- **Ask questions**: What are you learning here?... Why is this Physics concept important and how can it be used?... What do you not understand?... (For more information on this Physics topic, scan the QR codes in the *Real World Applications* and at the start of the *Procedure* section.)
- **Discuss** the concept and demonstration with your partner to help each other understand better. Discussion makes learning active instead of passive!
- For **FULL PARTICIPATION [15 points]** you must call on the TA when you have finished your group discussion to answer some comprehensive questions. If you do not fully understand and the TA asks you to discuss more, you must call on them one more time to be dismissed with full marks.
- **CONCLUSION [10 points]**: In the Conclusion section at the end of the worksheet, write 3 or more sentences summarizing this concept, how this lab helped you understand the concept better, and the real world implications you see. Do you still have questions? If so, write those as well.

Updated Date	Personnel	Notes
2023.03	Chase Boone, Udeshika Perera	2022 Summer Improvement: Created new format.

Name: _____ *PH1123* Section #:_____

Name: _____ TA Name:_____

HUMAN EYE
WORKSHEET [70 points]

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Memory exercise [each 2 extra credit points]:

M1) Waves travel as if other waves are not _____.

M2) Interference is a _____ of wave motion.

M3) Harmonics are _____ waves.

Accommodation

1) When switching from +62 to +120...
   a) Did the image become clearer? [1 point]

   b) Is the image larger or smaller than the actual object? [1 point]

   c) Is the image inverted or upright? [1 point]

   d) Explain why these things happened. [5 points]

Use of a Magnifier

Table 2: Magnification [18 points; 3 point per cell]

	Object height h_o	Image height h_i	Magnification $m = h_i / h_o$
Normal Eye			
+120 magnification			

Farsightedness and Nearsightedness

2) a) What is the focal length of the lens you used to correct farsightedness? [2 points]

b) Is that lens convex or concave in shape? [2 points]

c) Draw a light ray diagram of the setup. [5 points]

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3) a) What is the focal length of the lens you used to correct nearsightedness? [2 points]

b) Is that lens convex or concave in shape? [2 points]

c) Draw a light ray diagram of the setup. [5 points]

Astigmatism

4) a) What are the focal lengths of the pair of lenses you used to treat astigmatism and nearsightedness? [2 points]

b) Does it matter which order you place them in? [2 points]

Absence of the Crystalline Lens

5) a) What is the focal length of the lenses you used to correct this? [2 points]

b) Was the image completely clear? Why or why not? [2 points]

Impact of the Pupil

6) a) How was the image affected with the round pupil? (brighter, darker, clearer, less clear) [2 points]

b) How did the image change with the thinner pupil? What about after you moved the light source object? [2 points]

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Color Vision and Blind Spot

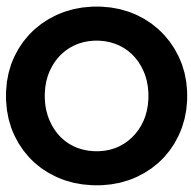
7) Based on Figure (7)... [1 point each]

a) At what angle did you see the random object?

b) At what angle did you see the color of the object?

c) At what angle did the shape disappear? (Use trigonometry between the distance of the shapes and the paper to your eye.)

d) Did the angles differ dramatically? Why?



Conclusion

Write 3 or more sentences summarizing this concept, how this lab helped you understand the concept better, and the real world implications you see. Do you still have questions? If so, write those here as well. [10 points]